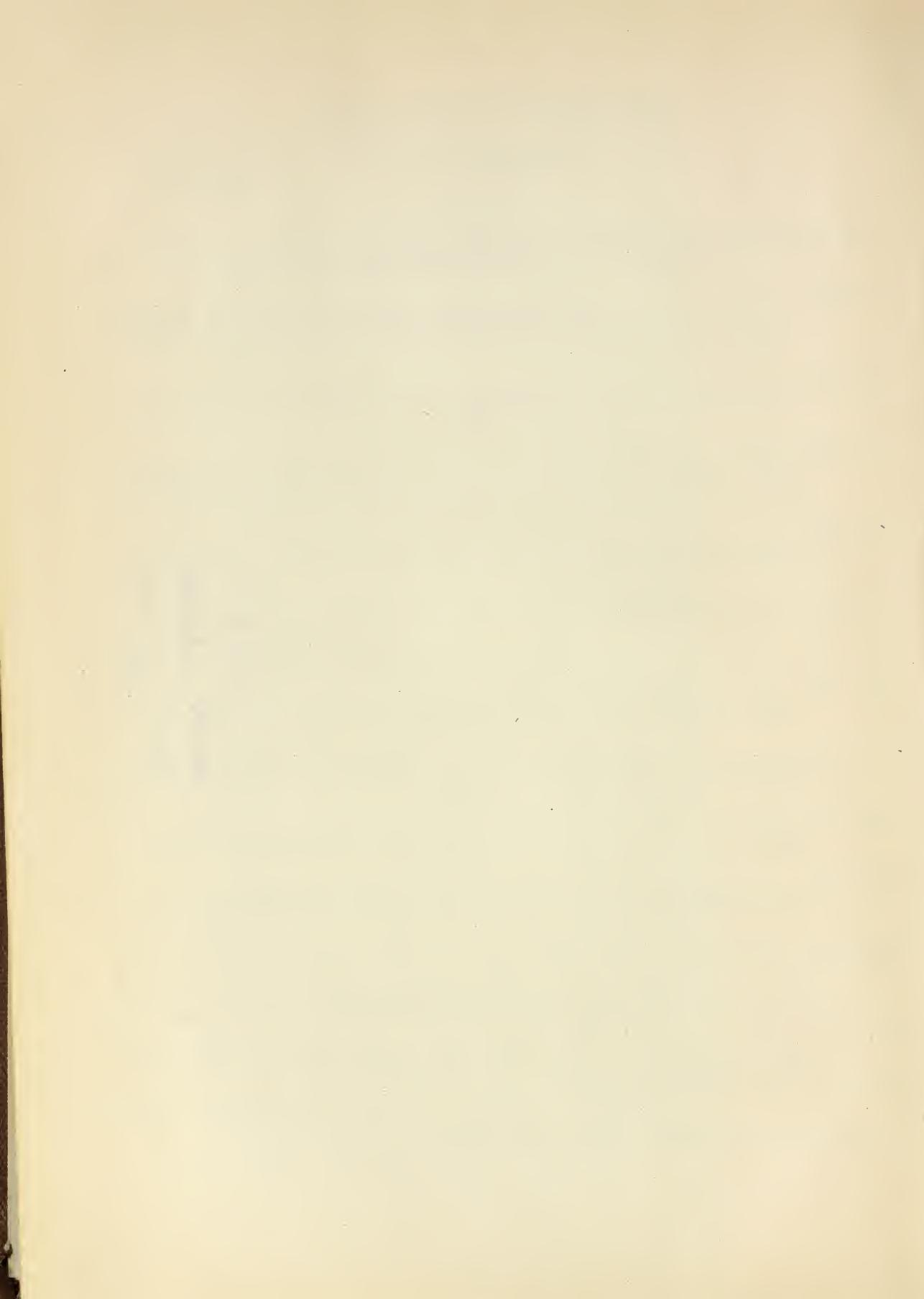


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SOUTHERN FOREST EXPERIMENT STATION

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FIRST-YEAR SURVIVAL AND HEIGHT GROWTH OF
COTTONWOOD PLANTATIONS AT STONEVILLE, MISS.

By

Henry Bull, Silviculturist
and

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Southern Forest Experiment Station

In cooperation with
Delta Experiment Station, Stoneville, Miss.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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Introduction

Most cut-over forest land in the bottomland hardwood region does not need to be planted to obtain another stand of timber. Natural reproduction usually is satisfactory in amount, although often predominated by relatively undesirable species. Cut-over areas that do need planting, however, are not uncommon. Very heavy cutting and repeated severe fires are largely responsible for this condition, but heavy overgrazing may also be a factor. Typical bottomland areas in need of planting support a scanty or negligible stand of low-grade and cull trees, and a very dense, tangled ground cover of weeds, brush, and vines. Since fast-growing trees are most likely to be successful in overcoming this severe competition, cottonwood is obviously an excellent prospect for planting. Fast-growing trees may produce somewhat less desirable and less valuable wood for some purposes than trees with slower growth rates, but on bottomland planting sites it may be a case of fast-growing trees or failure. Cottonwoods will yield merchantable pulpwood, or later sawlogs, in a comparatively short period. They will also shade out the dense ground cover and thus facilitate the later establishment of more slowly growing tree species, some of which may be of greater intrinsic value.

Besides general interest in the suitability of cottonwood for planting on most unstocked bottomland sites, there is special interest in the planting of cottonwood on Mississippi River batteure lands (i.e., lands between the levee and the river) to replace mature cottonwood after logging. Cottonwood is always replaced by a number of other hardwood species after logging, and new cottonwood stands originate only on bare land deposited by a river or abandoned by farmers. Since the species that replace cottonwood frequently are much less valuable, it is desirable to obtain another stand of cottonwood either by measures that will favor natural reproduction or by planting. For either course, there is very little information available on suitable methods or probable results.

Cottonwood Planting Experiments at Stoneville, Miss.

Location and History. A cooperative forest research program was begun by the Southern Forest Experiment Station and the Mississippi Agricultural Experiment Station in October 1939, with local headquarters at

the Delta Experiment Station, Stoneville, Miss. The object of this program is to conduct research on important forestry problems in the bottomland hardwood region. A typical cut-over forest of 2,580 acres, owned by the State, is available at Stoneville for demonstration and research, and two research projects are now in progress on this forest. One project, concerned with improvement cuttings, has been reported in a previous paper.^{1/} The other project, concerned with the planting of cottonwood, is reported here.

Experimental plantations of cottonwood cuttings and seedlings were established at Stoneville between January 30 and April 26, 1940. The plantations were examined June 18 - 21, 1940, to determine the early survival, and October 4 - 12, 1940, to determine the first-year survival and height growth. A report on the June examination was made in an earlier publication.^{2/} The present paper is a report on the October examination. Results obtained from the plantings of hybrid poplars are inconclusive thus far and are not further discussed in this report.

Purpose. The cottonwood planting study was designed to determine (1) whether cuttings or seedlings make the better planting stock, and (2) the effects of different planting sites, dates of planting, depths of planting and lengths of cuttings, and top-pruning treatments of seedlings. Supplementary information also was obtained on the characteristics of the most successful cuttings and seedlings, the effect of a single partial release from competition, the effect of using a rabbit repellent, and the growth of cuttings in the nursery.

There have been few previous studies of forest planting in the Delta; hence there was little background of experience for the present study. Valuable advice was obtained, however, from Mr. R. D. Stevens, of the Department of Horticulture and Forestry, University of Arkansas, who had recently made experimental cottonwood plantings in the Delta region of Arkansas.

Planting Sites. Two experimental plantations were established. One plantation occupies a well-drained "flat" that supported bottomland red oak, overcup oak, water hickory (bitter pecan), American elm, and other bottomland species. The other plantation is divided by a shallow slough into a "ridge" and a shallow swamp. The ridge site is higher than the flat, and once supported such species as redgum^{3/} and water oak. The swamp supported baldcypress, waterlocust, swamp privet,^{4/} and other swamp species, and was

^{1/} Putnam, J. A., and Henry Bull. Improvement cuttings in the bottomland hardwood forests of Mississippi. Occasional Paper No. 93. Sou. For. Expt. Sta. Oct. 22, 1940.

^{2/} Bull, Henry, and J. A. Putnam. Early survival of cottonwood and hybrid poplar plantations at Stoneville, Miss. Occasional Paper No. 94. Sou. For. Expt. Sta. Oct. 4, 1940.

^{3/} The common name recently accepted by the Forest Service for Liquidambar styraciiflora is sweetgum.

^{4/} Similarly, Forestiera acuminata is common adelia.

intermittently under water or waterlogged throughout the planting period. The flat is too wet in the spring for profitable agricultural use except in unusually dry years. The ridge is fair to good farm land, but the area is small and relatively inaccessible. The swamp is entirely unfit for farming, even though there is a large drainage canal within a quarter-mile.

To provide more uniform conditions for experimental purposes, and to facilitate the planting and later examinations, the largely low-grade and cull trees on the flat were girdled, and the sparse stand of similar trees on the other two sites was clear cut. On the flat the planting was done in narrow lanes cut through the dense brush, weeds, and vines with "Kaiser" blades (large ditch-bank blades or brush hooks). On the other two sites the entire planting area was cleared with Kaiser blades after the trees were removed. The brush, weeds, and vines sprouted vigorously in the spring and were 2 to 5 feet high in mid-June.

All three sites have heavy clay soils, whereas natural stands of cottonwood along river margins usually are on very much lighter soils that range from very fine sands to fine sandy loams. Cottonwood has been observed to grow well on almost any soil type in the Delta when once established, but the extent to which soil type affects establishment is not known. The most obvious reason why cottonwood usually is not abundant except along river margins is that moist, bare soils are seldom found elsewhere. Cottonwood seed is exceptionally light, fluffy, and perishable; it cannot reach the ground at all if vegetation is present, and after reaching the ground it must have continuously plentiful moisture to germinate and grow. Heavy clay soils usually do not occur along river margins, and seldom are moist and bare at the same time on cut-over lands. A few cottonwood cuttings were planted in Deer Creek fine sandy loam in the horticultural nursery at the Delta Experiment Station in March 1940, and although their survival was only slightly better than that of cuttings on the heavy clay of the cut-over land, their height growth was some 8 to 15 times greater. Since the cuttings in the nursery were cultivated several times and had no competition from other vegetation, the effect of soil type alone cannot be evaluated.

Since there is no conclusive evidence as to the relative advantages of heavy clay soils and much lighter soils in enabling cottonwood cuttings and seedlings to root themselves, the application of the results of the present study to much lighter soils is not known. It is thought, however, that the results would be at least as good—and probably better in an abnormal year like 1940—on lighter soils that contain much silt or fine sand and retain considerable moisture well into the summer. Results probably would be poorer on coarse sands that dry out rapidly during the summer.

Planting Stock and Methods. Cuttings from native cottonwood (*Populus deltoides virginiana*) were taken with pruning shears from vigorous 1-year-old shoots in the middle and upper parts of freshly felled trees in stands between the levee and the Mississippi River near Greenville, Miss. The trees were mostly 2 to 8 inches in diameter, although

a few were as large as 12 inches in diameter. "Fresh" cuttings were planted within 2 to 4 days after they were obtained, being heeled into the ground or stored in shallow water in the meantime. "Stored" cuttings were kept in cold storage at a temperature of about 35° F. between the time of preparation (March 4) and that of planting. Four different lengths of cuttings, two depths of planting for each length of cutting, and three dates of planting were tested with fresh cuttings. A single length of cutting and depth of planting at three different planting dates were tested with stored cuttings.

On the flat, the planting was done from January 30 to February 2, when cottonwood buds were completely dormant. On the other two sites the plantings included one while the cottonwood buds were still dormant (March 6 - 8 and 11), one at the time the buds were beginning to open (March 25 - 27), and two after the buds had opened in the woods (April 15 - 17 and 26). All cuttings were set in holes made with cylindrical planting bars. Bars of various diameters from 1/4 to 7/8 inch were used, depending on the diameters of the cuttings. An effort was made to obtain a tight fit for each cutting, and contact between the base of each cutting and the bottom of the hole.

Cottonwood seedlings were obtained from nearby ditches and borrow pits^{5/} for planting on the flat, and from stands between the levee and the Mississippi River for the other two sites. Seedlings 1½ to 7 feet high and mostly 2 years old were selected and pulled up without any digging. They were then planted, after just enough trimming of the roots to permit placing in holes made with the same planting bars used for the cuttings. The tops of some seedlings were left unpruned, while others were cut back to 2, 4, or 18 - 24 inches. Both fresh and stored seedlings were planted, the former at the same dates as the cuttings, but the latter on April 26 only.

Spacings of both 6 x 6 and 8 x 8 feet were used, but the results to date are most probably not affected by spacing.

Special Observations and Treatments. Certain obvious physical characteristics and measurements of the cuttings and seedlings planted on the flat were recorded for each plant, since it seemed likely that some item of appearance or size might be closely related to survival and growth. The data and the results are discussed in sections 3 and 5 under "Results."

After completing the planting on the flat, half of each test was treated with a rabbit repellent as a precaution against possible damage. The composition of the repellent and the interesting but unexpected results produced are discussed in section 12 under "Results."

In early June, the competing vegetation was so dense and tall that it was thought possible that certain tests might prove successful only if the cottonwood plants were at least temporarily and partially released from this severe competition. Half of each test on each site was therefore released. The character of the release and the results obtained are discussed in section 7 under "Results." Comparisons of released and unreleased stock are also mentioned in other sections.

^{5/} Source of material for levees or roads.

Unusual Growing Conditions and Insect Damage. At Stoneville the winter of 1939-40 was exceptionally cold and dry. The swamp was not flooded at all during this season immediately preceding planting. Conditions suitable for plant growth in the spring came into being about 3 weeks later than usual; it was unusually cool and wet until well into June, and unusually wet for a month longer. The ground remained cold and soggy long after the cottonwoods had fully developed leaves, and heavy rains flooded the swamp three times during March and April. All existing local records were broken by a very late killing frost, on April 13, and by heavy rainfall during late June and early July that flooded parts of the swamp to a maximum depth of 5 feet and resulted in standing water over most of the swamp for a period of about 10 days. Rains and floods of this nature are common in the region in January, but previously unrecorded in July. From the middle of July until November there was very little rain, and temperatures were normal or above normal. It is impossible to say exactly what effect these very unusual conditions had on the survival of the experimental plantings, but it seems certain that the conditions were unfavorable, especially to cuttings, because of their lack of roots when planted.

Insect damage was unusually widespread during the growing season, and at least three species of insects had a part in it. Poplar beetles were prevalent very early in the spring, then disappeared in May after defoliating relatively few plants. These beetles probably caused no actual mortality, but helped to weaken many individual plants. Later in the summer small, gray, woolly caterpillars became very numerous and defoliated a large proportion of the plantings. These caterpillars, which seemed to feed only on cottonwood and willow, defoliated many trees more than 50 feet tall. Local residents do not recall any previous attack of similar severity. In the plantations the caterpillars seemed to prefer the tallest, most vigorous, and most conspicuous plants and completely defoliated most of them. This injury occurred late in the season and it is doubtful that it caused any mortality. Grasshoppers caused considerable damage by chewing off patches and sometimes complete bands of bark. Such scars might have been mistakenly ascribed to mice or rabbits, except that they were usually found at heights to which these animals could not reach. Grasshoppers killed a few apparently well-rooted plants by girdling them, and caused much additional damage by chewing out terminal buds and girdling terminal shoots, which results in forked or crooked trees.

Analysis of Data

The plantations were planned and arranged in the field according to modern statistical techniques of replication and randomization, with four blocks on each site. A detailed analysis of variance to determine the statistical significance of the various survival percentages and average heights could be made, but is considered unnecessary. The study is exploratory and the main interest is in the larger, consistent differences that hardly need statistical measures of significance. Moreover, some small or inconsistent differences need further testing on a larger scale or in other years regardless of whether or not they are statistically significant in the present study. The results discussed below are based on a study of the size and consistency of survival percentages and average

heights, and involved many separate tabulations to bring out desired comparisons. Even large differences would of course have doubtful significance in the absence of proper replication and randomization; hence, the field arrangement has proved indispensable.

Results

For each test, the number planted and the percentages alive in June and in October are recorded in tables 1, 2, and 3. A complete examination was made in June, but in October the tests that it was thought would show less than 10 percent survival were not examined. The tests not completely examined in October are considered too poor for further study. Identification of the tests showing these unsatisfactory results was made from the records of the June examination, supplemented by an October examination of representative borderline cases. Table 4 lists the more successful planting stock for each site and planting date.

Table 1.—Summary of survival in June and in October 1940 of all cottonwood plantings made January 30 - February 2, 1940

Site: flat

Class of stock	Length of cutting	Depth of planting	Alive in June	Alive in October		Stock planted
				Not released	Released	
	- - - <u>Inches</u> - - -			- - <u>Percent</u> - -		<u>Number</u>
Fresh cuttings:						
Terminal ^{1/}	12	9	57	3	12	44
Nonterminal	12	9	45	5	20	44
Terminal	16	12	51	14	28	43
Nonterminal	16	12	50	11	50	44
Terminal	20	15	47	16	35	43
Nonterminal	20	15	53	19	44	43
Fresh seedlings:						
Top cut back to 2 inches				84	41	44
Not cut back				68	18	44

^{1/} A terminal cutting is one made from the end of a shoot, including the last or terminal bud.

Table 2.—Summary of survival in June and in October 1940, of unreleased cottonwood cuttings planted March 6 - April 26, 1940^{1/}

Kind of cut- tings	Length	Depth of plant- ing	2/ Site	Date of planting and dates of examination								Cuttings planted at each date	
				Mar. 6-8		Mar. 25-27		Apr. 15-17		April 26			
				June	Oct.	June	Oct.	June	Oct.	June	Oct.		
- Inches -													
<u>Fresh</u>	10	6	R	17	-	18	-	3	-			99-100	
	10	6	S	28	-	35	-	19	-			97-99	
	10	8	R	35	9	44	9	0	-			100	
	10	8	S	30	-	42	-	4	-			83-89	
	20	12	R	54	23	36	19	6	-			99-100	
	20	12	S	55	0	35	-	3	-			99-100	
	20	16	R	64	26	53	31	7	-			100	
	20	16	S	26	0	29	0	3	-			97-100	
	40	15	R	33	18	17	-	1	-			100	
	40	15	S	37	7	30	0	6	-			99-100	
	40	20	R	53	24	27	15	1	-			100	
	40	20	S	36	3	23	0	15	-			100	
	60	18	R	24	0	10	-	2	-			50	
	60	18	S	40	18	14	-	6	-			50	
	60	24	R	32	6	16	-	4	2			49-50	
	60	24	S	38	22	8	-	32	12			49-50	
<u>Stored</u>	20	16	R			71	27	53	13	53	2	100	
	20	16	S			35	0	55	2	54	0	98-100	

^{1/} In this and subsequent tables, a short dash (-) in a data column indicates that no data were recorded. See explanation under "Results," page 6.

^{2/} R = ridge; S = swamp.

Table 3.—Summary of survival in June and in October 1940, of unreleased cottonwood seedlings planted March 11 - April 26, 1940

Kind of seed- lings	Length after cutting back	Site ^{1/}	Date of planting and dates of examination								Seedlings planted at each date	
			Mar. 11		Mar. 25-27		Apr. 15-17		April 26			
			June	Oct.	June	Oct.	June	Oct.	June	Oct.		
Inches												
<u>Fresh</u>	4	R	88	44	92	18	8	-				12-25
	4	S	80	24	73	0	25	12				11-25
	18 - 24	R	80	24	69	35	15	-				13-25
	18 - 24	S	88	64	85	68	15	0				13-25
	n.c.b. ^{2/}	R	64	9	88	52	4	-				25-50
	n.c.b.	S	46	26	52	44	8	-				25-50
<u>Stored</u>	4	R							83	33	12	
	4	S							92	18	12	
	18 - 24	R							69	0	13	
	18 - 24	S							100	40	13	
	n.c.b.	R							48	0	25	
	n.c.b.	S							84	42	25	

^{1/} R = ridge; S = swamp.

^{2/} Not cut back.

Table 4.—Planting stock having best first-year survival, grouped according to site and planting date. All plantings having at least 18 percent survival are listed.

Site	Kind of stock ^{1/}	Planted March 6 - 8 and 11		Planted March 25 - 27		Planted April 26		Percent
		Survival		Survival		Survival		
		Not re- leased	Re- leased	Kind of stock ^{1/}	Not re- leased	Re- leased	Kind of stock ^{1/}	Not re- leased
Ridge	Fresh sdlgs. 4"	44	60	Fresh sdlgs. Uncut	52	44	Stored sdlgs. 4"	33
	Fresh ctgs. 20 - 16"	26	26	Fresh sdlgs. 20"	35	41		
	Fresh sdlgs. 20"	24	64	Fresh ctgs. 20 - 16"	31	39		
	Fresh ctgs. 40 - 20"	24	24	Stored ctgs. 20 - 16"	27	27		
	Fresh ctgs. 20 - 12"	23	31	Fresh ctgs. 20 - 12"	19	23		
	Fresh ctgs. 40 - 15"	18	20	Fresh sdlgs. 4"	18	61		
Swamp	Fresh sdlgs. 20"	64	80	Fresh sdlgs. 20"	68	70	Stored sdlgs. Uncut	42
	Fresh sdlgs. Uncut	26	42	Fresh sdlgs. Uncut	44	52	Stored sdlgs. 20"	40
	Fresh sdlgs. 4"	24	40					51
	Fresh ctgs. 60 - 24"	23	25					75
	Fresh ctgs. 60 - 18"	18	26					
Planted January 30 - February 2								
Flat	Fresh sdlgs. 2"							
	Fresh ctgs. NT, 20 - 15"	19	41					
	Fresh sdlgs. Uncut	18	58					

^{1/} The figures following "sdlgs" (seedlings) represent the height in inches to which they were cut back after planting. The figures following "ctgs" (cuttings) represent the length and the depth of planting, respectively, each in inches. NT = Nonterminal.

The principal results contained in the foregoing tables and in other data obtained in the study are discussed below in short, numbered sections. This method of presentation seems desirable in view of the large number of variables to be considered, and facilitates reference to the different topics. Survival percentages mentioned below are for unreleased plants unless specifically noted otherwise.

1. Seedlings vs. cuttings. In general, seedlings showed much higher survival than cuttings. Table 5 gives the best individual survival percentages for each class of stock for the different sites.

Table 5---Comparison of best results for seedlings and cuttings, in survival percent, classified according to planting site

Site	Fresh stock		Stored stock	
	Seedlings	Cuttings	Seedlings	Cuttings
Ridge	52	31	33	27
Flat	41	19		
Swamp	68	22	42	2

2. Time of planting. Plantings of fresh seedlings during the dormant period, and at the time cottonwood buds were beginning to open, resulted in approximately the same survival. Fresh cuttings, however, showed slightly better survival when planted during the dormant period than when planted at the time the buds were beginning to open. The two different dates of planting within the dormant period gave equally good results for both classes of stock. In marked contrast, plantings of fresh stock 2 to 3 weeks after the buds had opened were complete or almost complete failures.

Planted at the time the buds were beginning to open, fresh cuttings showed slightly higher survival than stored dormant cuttings of the same depth of planting and length. The fresh cuttings planted 2 to 3 weeks after the buds opened, however, had slightly lower survival. The stored cuttings that were planted at the time the buds were beginning to open showed best survival, those planted 2 to 3 weeks later poorer survival, and those planted 4 weeks later poorest survival.

The data indicate clearly that planting should be done during the dormant period, not later than the time the buds begin to open. If for any reason planting must be done later, stored dormant stock is preferable and should be planted as early as possible in the growing season.

3. Characteristics of the most successful seedling stock. The length of the top and the length of the roots at the time of planting were measured and recorded for the 88 seedlings planted on the flat. Records also were kept of the seedlings cut back to about 2 inches soon after planting. Root lengths varied from 3 to 14 inches and averaged 8 inches. The original top lengths varied from 19 to 82 inches and averaged 45 inches. The seedlings planted on the other two sites were not measured, but probably averaged about

4 inches more in root length and about 10 inches more in original top length. Their survival was somewhat better than that of the seedlings on the flat, indicating that the larger seedlings make better planting stock. Analysis of data for the measured seedlings indicates that the stock with the longer roots showed distinctly the better survival regardless of the length of the original top and regardless of whether or not the top was cut back. The 20 seedlings with roots at least 10 inches long showed 55 percent survival, whereas the 68 seedlings with shorter roots showed only 37 percent survival. Root length was by far the most important single factor measured.

4. Cutting back of seedlings vs. no cutting back. Table 6 shows how the effect of cutting back seedlings immediately after planting varied with the site and with the time of planting.

Table 6.—Percentages of survival in October for unreleased seedlings, classified according to cutting-back treatment, site, and time of planting

Site	Time of planting ^{1/}	Cut back to 2-4 inches	Cut back to 18-24 inches	Not cut back
Ridge	Complete dormancy	44	24	9
	Buds opening	18	35	52
	Leaves out ^{2/}	33	0	0
Swamp	Complete dormancy	24	64	26
	Buds opening	0	68	44
	Leaves out ^{2/}	18	40	42
Flat	Complete dormancy	41		18

^{1/} Phrases in this column refer to condition of nearby large cottonwoods.

^{2/} Stored stock was used at this time.

In the swamp, seedlings cut back to 18 - 24 inches generally showed highest survival, and those cut back to 4 inches lowest survival. On the ridge, however, highest survival was obtained either with seedlings cut back to 4 inches, or with seedlings not cut back, depending on the time of planting. These results indicate that cutting back improves survival when the plant cannot begin growth immediately, or when the supply of moisture is not abundant.

5. Characteristics of the most successful cuttings. The kind (terminal or nonterminal), diameter class, and numbers of large and of small buds were recorded for each of the 264 cuttings planted on the flat. Terminal cuttings (those made from the ends of shoots, including the last or terminal buds) showed the same survival as nonterminal cuttings where there was no release from competition, but consistently lower survival where released. This is shown in table 7, adapted from table 1.

Table 7.—Percentages of survival in October for fresh cuttings planted on the flat, classified by release treatment and kind of stock

Kind of stock	Not released	Released
12-inch cuttings:		
Terminal	3	12
Nonterminal	5	20
16-inch cuttings:		
Terminal	14	28
Nonterminal	11	50
20-inch cuttings:		
Terminal	16	35
Nonterminal	19	44
All lengths:		
Terminal	12	21
Nonterminal	12	36

The table also shows that survival increased with length regardless of whether or not the cuttings were released. On the other two sites, the best lengths were found to be 20 and 40 inches on the ridge, and 60 inches in the swamp (see next section).

For a given length and kind of cutting (terminal or nonterminal), diameter or thickness apparently did not affect survival. The numbers of large and of small buds on a cutting showed no strong or consistent relationship to survival.

6. Depth of planting and length of cuttings in relation to site. Table 8 shows the best survival percentages for different depths of planting and lengths of fresh cuttings on the ridge and in the swamp.

Table 8.—Best October survival percentages for fresh cuttings of various lengths, grouped by site and mode of planting

Length of cutting (inches)	Ridge		Swamp	
	Shallower planting	Deeper planting	Shallower planting	Deeper planting
10	0	9	0	0
20	23	31	0	0
40	18	24	7	3
60	0	6	18	22

It is evident that 20- and 40-inch cuttings are best on the ridge, and that 60-inch cuttings are best in the swamp. The failure of short cuttings in the swamp probably is due largely to the smothering competition of

dense weeds at the time the cuttings were trying to get rooted. Seedlings in the swamp, even though they had roots to start with, showed their poorest survival when most severely cut back.

Relatively deep planting produced the better results on the ridge, but in the swamp the effect of different depths of planting is indefinite.

7. Effect of a single partial release from competition in June. A single partial release from competition was accomplished by "chopping" away competing vegetation around each plant with a cotton-chopping hoe to a radius of about 1-1/2 feet in half of the rows devoted to each separate test.

Table 9.—Average survival and total height of released stock expressed as percentages of the averages for unreleased stock^{1/}

Kind of stock	Survival			Total height		
	Ridge	Flat	Swamp	Ridge	Flat	Swamp
<u>Fresh cuttings:</u>						
10 - 12 inches long	150	438	100	86	140	-
16 - 20 " "	121	256	(2 to 0)	144	130	-
40 " "	112		164	109		82
60 " "	126		100	140		86
<u>Stored cuttings:</u>						
20 inches long	162		(0 to 2)	143		-
<u>Fresh seedlings:</u>						
Cut back to 4 inches	167	102	238	104	114	122
Cut back to 18 - 24 in.	203		117	113		110
Not cut back	143	333	140	100	108	99
<u>Stored seedlings:</u>						
Cut back to 4 inches	100		(0 to 20)	105		-
Cut back to 18 - 24 in. (20 to 0)			187	-		138
Not cut back	(33 to 0)		122	-		104

^{1/} When one survival percentage is 0 and the other is 1 or more, the latter is infinitely greater. In such cases, to give a better picture of the actual comparison, both survival percentages are given; e.g., (20 to 0) means that the released stock has the better survival: 20 percent vs. 0 percent for the unreleased stock.

It is evident that partially released stock of all classes generally surpassed unreleased stock in both survival and total height. In general, the partial release was more effective in increasing survival than in increasing total height.

8. Total heights attained in the first growing season. A brief summary of the average total heights attained in the first growing season is given in table 10, based on fresh stock, not released.

Table 10.—Average total height of unreleased stock in October, in inches

Kind of stock	Ridge	Flat	Swamp
Cuttings:			
10 ~ 12 inches long	7	5	0
16 .. 20 inches long	9	8	0
40 " "	23		56
60 " "	30		57
Seedlings:			
Cut back to 2 - 4 inches	24	22	49
Cut back to 18 - 24 inches	38		61
Not cut back	44	25	78

The effect of release on total height is shown in the preceding section. Storage and date of planting had relatively little effect on total height.

9. Form of surviving cuttings and seedlings. In general, the form or straightness of surviving cuttings and seedlings is satisfactory from the standpoint of future sawlog or pulpwood production. The stock on the ridge is especially good in this respect, although a few trees there may not straighten satisfactorily as they grow larger. In the swamp, however, about one-third of the plants have a definitely unsatisfactory form. In most cases, poor form is caused by interference from the extremely heavy ground cover of shrubs, weeds, and vines. Buckvine, the worst offender, has frequently caught and pulled down the young cottonwoods and forced them to grow almost horizontally through entangling vegetation. In some cases the surrounding vegetation has nothing to do with the poor form; the young cottonwoods simply start their new growth above a very crooked or leaning portion of the plant. Grasshoppers, and possibly other insects, also contribute to poor form by eating the terminal buds and by girdling the main shoots. Girdling kills the trees if no new sprouts are put out below the girdle.

Since in most cases the trees with a very unsatisfactory form will have a relatively low commercial value in the future, and in most cases will never even reach commercial size, these trees should be cut back at or very close to the ground during winter or early spring, and thus forced to sprout again. Straight sprouts—but perhaps multiple rather than single sprouts—should result from this treatment. Although the new sprouts may again be caught and deformed by vines, the danger is not so great as before, since the new sprouts will have the advantage of an established root system and probably will outgrow the vines. The need for cutting back about one-third of all stock planted in the swamp makes an extra expense to charge against this site, but it may well be counterbalanced by better survival, better growth, and the probability that in the swamp a planted stand has greater advantages over a possible natural stand than it would have on other sites.

10. Differences in survival between ridge and swamp plantings. Of the 8 plantings of cuttings with survivals of 18 percent or better in October, 6 are on the ridge and only 2 are in the swamp. Of the 13 plantings of seedlings with the same minimum survival, 6 are on the ridge and 7 are in the swamp, with the 2 highest survival percentages in the swamp. Cuttings evidently are far better adapted to the ridge, whereas seedlings are not so sensitive to site but do slightly better in the swamp.

These facts, and several others already discussed concerning depth of planting and length above ground, indicate that survival on the ridge depends largely on having a considerable length in the ground (to obtain sufficient moisture), and only a comparatively short length above ground (so that drying out will not be excessive). The poor survival of 10-inch cuttings on the ridge, for example, is probably due largely to the short length in the ground. Survival in the swamp apparently depends largely on having a considerable length above ground so that the new shoots can begin growth at a level close to or above the tops of the exceptionally dense competing vegetation. The plentiful or excessive moisture in the swamp presumably makes it unnecessary to plant deeply or to leave only a short length above ground. In addition to heavy competition, another condition in the swamp that makes necessary a long length above ground is the frequent presence of standing water deep enough to submerge and kill short lengths.

11. Mortality between June and October, and factors affecting it. In every test the survival recorded in October is lower than the survival recorded in June, and in most cases it is much lower (see tables 2 and 3). The plantings that ranked at or near the top in June usually ranked at or near the top in October also, but there are a few striking exceptions, all in the swamp tests. For example, fresh 20-inch cuttings planted 12 inches deep in early March dropped from 55 to 0 percent survival; fresh seedlings planted in late March and cut back to 4 inches dropped from 73 to 0 percent survival; and stored seedlings planted in late April and cut back to 4 inches dropped from 92 to 18 percent survival. It is notable that all of these plantings are of relatively short lengths above the ground in the swamp.

The plantings showing good results both in June and in October generally had from one-half to two-thirds as high survival in October as at the earlier date. Seedlings as a rule showed lower losses than cuttings during the summer, although on the ridge the best plantings of each class of stock show virtually the same losses. Stored stock showed considerably heavier losses during the summer than fresh stock. With respect to sites, the best plantings of both seedlings and cuttings usually showed smaller losses during the summer in the swamp than on the ridge, whereas the poorer plantings showed exactly the opposite result. Losses between June and October seemed to have no appreciable relation to date of planting.

In most cases, cuttings that were alive in June but dead in October either had no roots or very meager roots, a fact revealed by pulling up many of them in October. Similarly, most of the seedlings that died during the summer probably had no live roots in June. In the swamp, heavy vegetation and late floods probably were largely responsible for killing the tops of many plants that had leafed out in June, weakening whatever root growth had started. It is possible that most of the plants that were leafed

out in June had little or no root formation, and that roots did not develop during the summer except under favorable conditions of soil moisture, retention of moisture in the tops, and competition with other vegetation.

12. Effect of rabbit repellent. The rabbit repellent was prepared by stirring 5 pounds of liquid asphalt paint into 3-1/3 quarts of water, adding 3-1/3 pounds of copper carbonate, and then enough water to make up 4 gallons. This was sprayed or painted on the planting stock in 2 of the 4 blocks on the flat, and produced an unexpected result. It proved to be unnecessary to protect the plantings from rabbits, since no rabbit damage was noted later in the untreated blocks. Survival data for treated stock, however, expressed as percentages of the survival of untreated stock on the same site, were as follows:

	<u>June</u>	<u>October</u>
Cuttings	116	157
Seedlings	112	70

It is thought that the differences in favor of the treated cuttings are the result of conservation of moisture brought about by the repellent coating. Probably the asphalt in the repellent was largely responsible for this action. The fact that the seedlings eventually did not survive better in the treated plots fits well into this theory only if it is assumed that seedlings are much less or not at all in need of protection from loss of moisture. This is not unlikely, however, since seedlings benefit from having roots when planted, and tops that generally seem to be less succulent and to have tighter bark than cuttings. For these reasons, seedlings probably are more capable of maintaining adequate moisture.

13. Possibility of improved results through selection of stock. The results discussed in this paper were obtained without careful selection of stock. In the case of cuttings, material was obtained at random from 1-year-old shoots from the upper parts of the crowns of well-developed saplings and small trees without any discrimination other than to discard a few very crooked, weak, or injured shoots. In the case of seedlings, 1- and 2-year-old plants were taken at random, again discarding only very crooked, weak, or injured seedlings. In the use of either cuttings or seedlings, however, especially cuttings, it is probable that careful selection of stock of only a certain appearance or character, or from trees of only a certain appearance or character, will greatly improve survival and growth. At present there is no basis for such selection, but studies designed to explore this field will be commenced soon at Stoneville.

Conclusions and Recommendations

Based on results obtained solely on clay soils and in a single, abnormal growing season, conclusions are necessarily tentative and may be modified by further studies. In view of the demand for information that can be put to immediate practical use, however, it is desirable to present conclusions and recommendations at this time.

Present indications are that wild cottonwood seedlings (wildlings) are better than cuttings for planting stock. Seedlings should be obtained and planted before the buds open in the spring, or obtained early and held in cold storage if for any reason the planting can be done only after growth has started. Fresh, dormant stock planted very soon after pulling is preferable, and it must not be allowed to dry out before planting. Seedlings may be obtained from natural stands close to the Mississippi or other large rivers, or in borrow pits and ditches. In swamps and low flats the seedlings should be cut back to about 18 - 24 inches at the time of planting. On ridges or high flats the seedlings should be cut back to about 4 inches if the planting is done at least 2 weeks in advance of the opening of the buds, or if the stock has been stored and is planted after growth has started in the woods; otherwise the seedlings should not be cut back. The seedlings should be approximately 2 years old, or about 4 to 7 feet high, and the roots should be at least 10 inches long.

In view of the probable survival percentages of about 50 percent on ridges and 70 percent in swamps for the first year, a spacing of about 6 x 6 feet seems more suitable than wider spacings. At least one partial release from competition in June appears desirable but not essential. During the dormant period following the first growing season, crooked and deformed seedlings and those interfered with by vines should be cut back just above the ground. Since total heights will probably average about 3 feet on ridges and 5 feet in swamps, it should not be difficult to find the seedlings that will benefit from cutting back.

If seedlings cannot be obtained, cuttings may be used. On ridges or high flats, cuttings should be 20 inches long and planted 16 inches deep. In swamps and low flats, cuttings should be 60 inches long and planted 24 inches deep. The stock should be obtained and planted before the buds open in the spring, and must not be allowed to dry out before planting. Cuttings that do not include the terminal bud are preferable. Recommendations concerning spacing, release from competition, and the cutting back of crooked plants after the first growing season are the same as for seedlings.